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Sensitivity and specificity of the Manchester Triage System in risk prioritization of patients with acute myocardial infarction who present with chest pain

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Abstract

Background: The purpose of the Manchester Triage System is to clinically prioritize each patient seeking care in an emergency department. Patients with suspected acute myocardial infarction who have typical symptoms including chest pain should be classified in the highest priority groups, requiring immediate medical assistance or care within 10 min. As such, the Manchester Triage System should present adequate sensitivity and specificity.

Aims: This study estimated the sensitivity and specificity of the Manchester Triage System in the triage of patients with chest pain related to the diagnosis of acute myocardial infarction, and the associations between the performance of the Manchester Triage System and selected variables.

Methods: This was an observational, analytical, cross-sectional, retrospective study. The sensitivity and specificity of the Manchester Triage System were estimated by verifying the triage classification received by these patients and their established medical diagnoses.

Results: The sample was composed of 10,087 triage episodes, in which 139 (1.38%) patients had a diagnosis of acute myocardial infarction. In 49 episodes, confirmation of medical diagnosis was not possible. The estimated sensitivity of the Manchester Triage System was 44.60% (36.18–53.27%) and the estimated specificity was 91.30% (90.73–91.85%). Of the 10,038 episodes in which the diagnosis of acute myocardial infarction was confirmed or excluded, 938 patients (9.34%) received an incorrect classification – undertriage or overtriage.

Conclusion: This study showed that the specificity of the Manchester Triage System was very good. However, the low sensitivity based on the Manchester Triage System indicated that patients in high priority categories were undertriaged, leading to longer wait times and associated increased risks of adverse events.

Keywords

Myocardial infarction, triage, sensitivity and specificity

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Introduction

The emergency department (ED) has invested significant effort into organizing patient flow based on triage systems that prioritize care according to patients' degrees of risk and severity. Acute myocardial infarction (AMI) is a significant cause of morbidity and mortality throughout the world.[1] One of its main manifestations is chest pain,[2] which often

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Table 1. A 2×2 contingency table with criteria that determined the classification of the true positives and true negatives, false positives and false negatives, related to the diagnosis of acute myocardial infarction (AMI) and appropriate prioritization according to the Manchester Triage System (MTS).

		Diagnosis of AMI	
		Positive	**Negative**
MTS Result	**Positive**	Red/Orange AMI (+) TP	Red/Orange AMI (-) FP
	Negative	Yellow/Green/Blue AMI (+) FN	Yellow/Green/Blue AMI (-) TN

Legend: AMI - acute myocardial infarction; TP-true positives; FP-false positives; FN-false negatives; TN-true negatives.

leads the patient to seek ED treatment. This article presents a study evaluating the performance of the Manchester Triage System (MTS) in the prioritization of care for patients arriving at the ED with complaints of chest pain and a diagnosis of AMI.

The MTS is widely used to classify patients into one of five priority levels. Each level is represented by a color that indicates the response time limit within which the patient should be safely attended.[3]

When using the MTS for evaluation, patients with suspected AMI who have typical symptoms such as chest pain should be classified in either red or orange levels of priority, defined by a need for immediate medical assistance, or assistance within 10 min, respectively.[3,4] This requires adequate sensitivity and specificity of the MTS.

In a systematic review using the methodology of the Joanna Briggs Institute,[5] whose report included six studies totaling 54,176 participants, the sensitivity of the MTS in the evaluation of patients with acute coronary syndrome (ACS) ranged between 0.70–0.80, while the specificity measures, calculated in only two of the studies included, were 0.59 and 0.97.[6]

The objectives of this study comprised an estimation of the sensitivity and specificity of the MTS in the triage and adequate prioritization of patients with chest pain and suspected diagnosis of AMI. We also aimed to identify possible associations between the performance of the MTS and selected variables, which could ultimately provide evidence for improvement of the functionality of this system in the evaluation of patients with AMI.

Methods

This was an observational, analytical, cross-sectional, retrospective study developed at a general teaching hospital in the city of São Paulo, Brazil. This hospital has 178 beds and there are approximately 200,000 ED visits per year. The MTS was implemented at the institution in May 2012 and is performed by trained nurses.

The sensitivity and specificity of the MTS in the evaluation of patients with chest pain were estimated by verifying the triage level assigned to these patients according to the MTS and the medical diagnosis established. According to the American Heart Association recommendations,[4] the MTS was defined as positive when the patient was classified as red (immediate) or orange (very urgent) (Table 1). Data were collected from visits conducted between July 2012–June 2017 for patients aged 18 years or older who presented with chest pain.

We identified patients who received a diagnosis of AMI after verification of serum troponin and confirmation by review of the medical record documentation. The flow diagram (Figure 1) details the sample selection process.

In addition to the MTS and the medical diagnosis, the demographic and clinical data of the patients were collected.

Positive predictive values (PPVs) and negative predictive values (NPVs) were calculated in addition to the positive and negative likelihood ratios. For each estimate, 95% confidence intervals (CIs) were calculated. Associations between the categorical variables and the risk classification results were established using the Chi-square and Fisher's exact tests. The means and standard deviations (SDs) were determined for continuous variables, and associations between the variables and the results of triage were established using the Kruskal-Wallis and Wilcoxon-Mann-Whitney tests. Tests that presented values of $p<0.05$ were considered statistically significant. The research protocol was submitted to and approved by the Research Ethics Committee of the Institutions involved with the study.

Results

The study sample comprised 10,087 triage episodes, of which 139 (1.38%) included a diagnosis of AMI confirmed by the medical record, 9899 (98.14%) received diagnoses other than AMI and in 49 (0.48%) episodes, troponin results were available, but it was not possible to verify the medical diagnosis because the medical records were incomplete or were not located. The characterization of the study population (n=10,087) and the subgroup of patients with a diagnosis of AMI (n=139) are presented in Table 2.

Of the patients treated in these 10,087 episodes, the mean age was 43.58 years (SD=17.56), there was a slight predominance of women, and four patients with no record of age were excluded from the age and age range analysis. Forty-nine of the triage episodes included a positive troponin result, but without the possibility of excluding or confirming the medical diagnosis of AMI, we had to exclude these from the analysis of the sensitivity and specificity of the

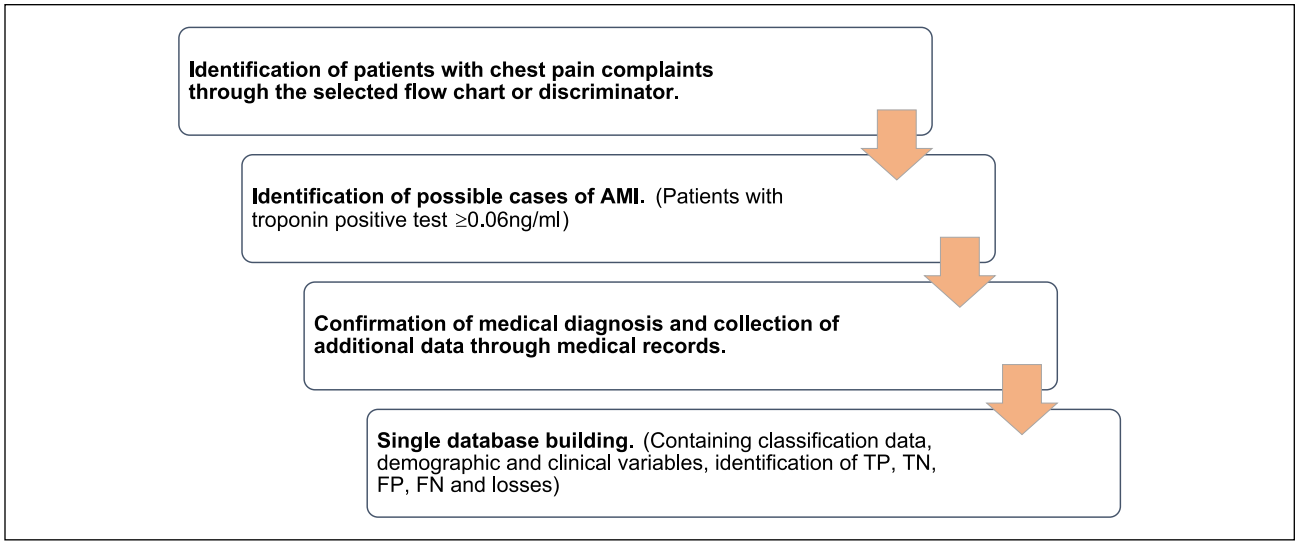

Figure 1. Flowchart of the study population selection process.
AMI: acute myocardial infarction; FN: false negative; FP: false positive; TN: true negative; TP: true positive.

Table 2. Demographic characteristics of the study population: the subgroup of patients with a diagnosis of acute myocardial infarction (AMI) and data regarding the triage level, length of hospital stay, and outcome of care in the emergency department.

Variables	Triage episodes with a record of chest pain(*n*=10,087)		Triage episodes with a confirmed diagnosis of AMI (*n*=139)	
Sex	***n***	%	***n***	%
Women	5273	52.28	42	30.22
Men	4814	47.72	97	69.78
Age[a]	***n***	%	***n***	%
15–39 years	4632	45.94	1	0.72
40–64 years	4061	40.28	88	63.31
65–89 years	1343	13.32	47	33.81
90 years or more	47	0.47	3	2.16
Color established by MTS	***n***	%	***n***	%
Blue	1267	12.56	–	–
Green	5050	50.06	11	7.91
Yellow	2822	27.98	66	47.48
Orange	946	9.38	62	44.04
Red	2	0.02	–	–

MTS: Manchester Triage System.
[a]Missing data in four episodes.

MTS in the classification of patients with AMI. A 2×2 contingency table was constructed using the data of 10,038 episodes in which there were records of chest pain at the time of triage, and for which it was possible to exclude or confirm the diagnosis of AMI (Table 3).

Based on the data presented, we estimated the sensitivity and specificity and other properties of the MTS (Table 4).

The associations between the appropriate triage (red or orange for patients with AMI and yellow, green, or blue for patients without AMI) and the sex, age, and outcome of the emergency care of the 10,038 triage episodes in which it was possible to retrieve this information, are presented in Table 5.

A statistically significant association was observed between age and the performance of the MTS, with smaller proportions of correct classifications in the higher ranges, as well as between the outcome of care in ED and the performance of the MTS. Disregarding the outcomes "discharge requested" and "death," the highest frequencies of correct classification occurred in the outcome "referral to other units," followed by "dropout" and "home discharge" (Table 5).

Table 3. A 2×2 contingency table of the triage by Manchester Triage System (MTS) in the evaluation of patients with chest pain and a medical diagnosis of acute myocardial infarction (AMI).

Classification by MTS	Diagnosis of AMI		Total
	Yes	No	
Positive test (orange or red)	62	861	**923**
Negative test (blue, green or yellow)	77	9038	**9115**
Total	**139**	**9899**	**10,038**

Table 4. Calculated values for Manchester Triage System (MTS) properties in the adequate triage of patients with chest pain in relation to the medical diagnosis of acute myocardial infarction (AMI).

Property	Calculated value	95% CI
Sensitivity	44.60%	36.18–53.27%
Specificity	91.30%	90.73–91.85%
Prevalence	1.38%	1.17–1.63%
Positive predictive value	6.72%	5.19–8.53%
Negative predictive value	99.16%	98.95–99.33%
Positive likelihood ratio	5.13	4.22–6.24
Negative likelihood ratio	0.61	0.52–0.70

CI: confidence interval.

Association tests between the color established by risk classification and selected variables were performed using the data of the patients with a diagnosis of AMI (n=139) (Table 6).

Regarding the interventions described in Table 6, some patients may have been subjected to more than one of them, and some may not have been subjected to any of the interventions selected in this study.

Discussion

In the present study, the sensitivity of the MTS in appropriately triaging patients with AMI was 46.60% (95% CI: 36.18–53.27%), while the specificity was 91.30% (95% CI: 90.73–91.85%).

The sensitivity found in the studies of a systematic review addressing the same issue[6] can be compared with the results of this primary study. The sensitivities reported in the studies of the systematic review varied between 70–80%,[6] calling attention to the sensitivity of 44.60% (Table 4) obtained in this study, which was far less than in the other studies.

A large proportion of patients with AMI screenings were assigned to a lower priority level (yellow) than appropriate (undertriage). One of the explanations for this fact may lie in the physical structure of the organization and the flow of care at the study site. Patients classified as in a yellow, orange, or red triage group are instructed to wait in a waiting room close to the emergency room and the resources needed to available to attend emergency situations, and where there is a constant presence of doctors and medical students. Patients classified as green or blue await medical care in a space farther from the emergency room. One can speculate that the nurses who perform the triage may assign patients to the orange and the yellow groups without a clear discrimination between them. This could contribute to the low sensitivity of the MTS in patients with AMI. We also observed a low proportion of patients classified in the red priority level, likely also due to patient flow issues, such that patients may have bypassed triage altogether.

The institutional context, especially the flow of care, can exert great influence on the estimated values used to assess the MTS, and may have contributed to the occurrence of undertriage in this study population.

Associations were found between the adequate classification of patients with a diagnosis of AMI using the MTS, and age range. This association could also be observed in the outcomes of care provided in the ED, since more than 90% of the patients classified in the lowest priority levels were discharged from hospital after attendance in the ED (Table 5).

In a study developed in Europe[7] that evaluated the performance of the MTS in three different hospitals, sensitivities of 47%, 72% and 87% were identified in each of the institutions and the specificities were 94%, 87% and 84%. In this same study, the percentage of patients with chest pain that were triaged correctly did not exceed 55% in the hospital that presented the best rate of correct classifications for patients triaged using the chest pain flowchart. More than 20% of the patients were undertriaged in the hospital that displayed a higher rate of undertriage using the chest pain flowchart. When comparing those results with the ones in the present study, it should be noted that the sensitivity and specificity values of 44.6% and 91.3% are very close to the values of the first institution cited, in which the MTS showed worse sensitivity and better specificity. In 2011, Storm-Versloot et al. reported a specificity of 100% and 95% in the American triage system – the Emergency Severity Index (ESI) - for patients in the two highest priority levels respectively.[8] In another study, a specificity of 91% for the ESI was reported when applied to patients with all types of complaints.[9]

When comparing the values of specificity of the MTS reported in a systematic review[6] with the data from the present study, we also observed the differences and similarities between the studied populations in terms of the inclusion criteria of the patients. While the specificity of the MTS for patients with AMI in the present study was 91.30% (Table 4), the specificity was 59% in another study

Table 5. Association between the performance of the Manchester Triage System (MTS) in relation to the diagnosis of acute myocardial infarction (AMI), and the sex, age, and destination of discharge from emergency department (ED) of patients with chest pain (*n*=10,038).

Variable	Correct triage level (TP+TN) *n* (%)	Incorrect triage level (FP+FN) *n* (%)	Tests
Sex			
Women	4.763 (90.70%)	490 (9.30%)	*p*=0.953[a]
Men	4.337 (90.60%)	448 (9.40%)	
Age[b]			
15–39 years	4.441 (95.98%)	186 (4.02%)	
40–64 years	3.531 (87.57%)	501 (12.43%)	
65–89 years	1.093 (82.24%)	236 (17.76%)	*p*<0.001[c]
90 years or more	33 (71.74%)	13 (28.26%)	
Destination of discharge from ED			
Home discharge	8.623 (91.64%)	787 (8.36%)	
Dropout	221 (89.47%)	26 (10.53%)	
Hospitalization	130 (59.36%)	89 (40.64%)	
Referral to a lower complexity service	102 (99.03%)	1 (0.97%)	*p*<0.001[a]
Referral to another hospital	21 (39.62%)	32 (60.38%)	
Discharge requested by the patient	3 (100%)	– (–)	
Death	– (–)	3 (100.00%)	

FN: false negative; FP: false positive; TN: true negative; TP: true positive.
Dropouts: patients who withdrew from care at any time following their triaging; referral to another hospital: patients who were initially treated at our hospital, but were transferred to another hospital for further diagnostic and/or therapeutic procedures; hospitalization: patients who were admitted to any facility within our hospital; referral to a low complexity service: patients who were referred to ambulatory or walk-in centers.
[a]Pearson's chi-square; [b]missing data in four episodes; [c]Wilcoxon-Mann-Whitney test.

Table 6. Association between the color of the triage and sex, type of acute myocardial infarction (AMI), risk factors for cardiovascular disease and therapy for patients with a confirmed diagnosis of AMI (*n*=139).

Association variable	Color established in the evaluation by the MTS						*p* Value[a]
	Orange		Yellow		Green		
	n	%	*n*	%	*n*	%	
Sex							0.007
F	18	42.86%	16	38.09%	8	19.05%	
M	44	45.36%	50	51.55%	3	3.09%	
Type of infarction							0.065
STEMI	16	43.24%	21	56.76%	–	–	
NSTEMI	46	45.10%	45	44.12%	11	10.78%	
Risk factor							
Hypertension	46	48.94%	43	45.74%	5	5.32%	0.260
Diabetes	18	46.15%	17	43.59%	4	10.26%	0.197
Smoking	28	54.90%	19	37.25%	4	7.84%	0.289
Dyslipidemia	28	54.90%	20	39.22%	3	5.88%	0.387
Therapy							
Angioplasty	16	42.11%	20	52.63%	2	5.26%	0.281
Thrombolysis	9	52.94%	8	47.06%	–	–	0.491
Cardiac catheterization	48	43.24%	53	47.75%	10	9.01%	0.565

MTS: Manchester Triage System; NSTEMI: non-ST segment elevation myocardial infarction; STEMI: ST segment elevation myocardial infarction.
[a]Value of *p* calculated by Fisher's exact test.

that also included only patients with chest pain.[10] Such differences may also be attributed to the differences in the contexts in which the studies were carried out, particularly regarding the organization of the visits flows and the flows in the study site. In general, these two variables are interdependent, which means that it is possible to increase the specificity by reducing the sensitivity and vice-versa.[11]

The minor variations in the predictive values found in the studies included in the systematic review,[6] which are not very distant from our results (Table 4), show that, even in populations with different characteristics and different prevalences of ACS, the performance of the MTS remains stable. The lowest PPV observed in this study (6.72%; 95% CI: 5.19–8.53%; Table 4) compared to the studies of Pinto et al. (14%; 95% CI: 12–16%)[12] and Leite et al. (16%; 95% CI: 10–25%)[10] can be attributed to the fact that the present study only assessed patients diagnosed with AMI, while the other two studies assessed patients with any ACS.

Although it was not possible to establish an association between the patients' sex and the performance of the MTS (Table 5), a statistically significant association was observed between sex and the color code established based on the MTS (p=0.007) in the subgroup of patients with AMI (Table 6). As the MTS is based on signs and symptoms, this association may be related to the differences between the symptoms described by men and women. A recent study showed that among patients with ACS, men reported chest pain with greater frequency, while in women pain was reported in the shoulder or back.[2] Variables such as risk factors, the type of AMI, and established therapy showed no association with the color code set by the MTS for patients with AMI (Table 6).

Although there is no way to determine the acceptable sensitivity and specificity values of the MTS in the triage of patients with ACS or AMI, the results of this study highlight the need to discuss ways to improve the sensitivity of the MTS with regard to the evaluation of patients with chest pain suggestive of myocardial ischemia. The results presented here can also guide management decisions, especially regarding the choice and implementation of institutional protocols in ED triage. This is a decision that should be made considering the profile of the patients attended at the institution, and the performance of exams in the initial triage process.[13]

The purpose of the MTS should be taken into consideration when conducting surveys that evaluate its performance. As a triage test, it does not necessarily require high precision, but should be simpler and less costly than the definitive diagnosis.

Limitations and future research

One limitation of this study is the fact that the patients treated in the ED at night and also those who directly entered the emergency room did not pass through triage, possibly indicating higher acuity of those patients. The exclusion of these patients may result in an underestimation of the performance of the MTS.

Conclusions

This study showed that the specificity of the MTS to the correctly prioritize patients with chest pain suggestive of myocardial ischemia was very good. However, the low sensitivity indicated that patients in high priority categories were undertriaged based on the MTS, leading to longer wait times and associated increased risks of adverse events, and delays of treatment.

Implications for practice

- Although the Manchester Triage System (MTS) is a protocol developed for the evaluation of a patient with any complaint, its use in patients with acute myocardial infarction should take into account some of its weaknesses.
- The institutional flow should be evaluated and readjusted in order to provide a greater accuracy of the MTS.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

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